Development of the Brine Residual in Containment Concept

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Technology improvements in the recovery of water from brine are critical to establishing full-closure water recovery systems and achieving a sustained human presence in space. The NASA Exploration Life Support Project initiated a brine dewatering task to survey, develop, and test technologies for extracting water from concentrated wastewater brines. In response to this effort, the NASA Johnson Space Center Advanced Water Recovery Systems group proposed developing a novel brine dewatering concept that is referred to as brine residual in-containment (BRIC). The BRIC concept aims to address specific challenges associated with designing reliable systems that can approach 100% water recovery from brine. These issues include the buildup and removal of sticky and potentially toxic brine solids that tend to foul process equipment and reduce the overall efficiency of heat transfer and solids removal.

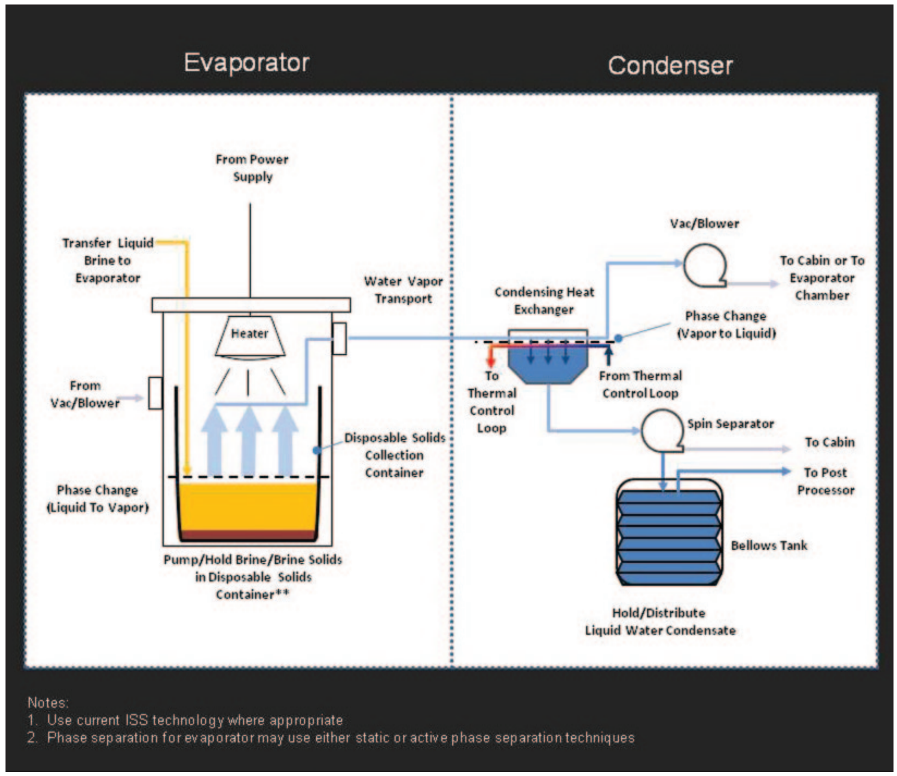

Fig. 1. *Simplified schematic of brine residual in-containment concept.*

The BRIC concept implements a technique in which brine drying is effected within the container used for final disposal of solid residual waste in an attempt to obviate some of the design complexity associated with removing and transporting brine solids. The practice of in-place drying has some precedence in the nuclear waste industry, where it has been proposed for use in minimizing disposal volumes and reducing human exposure to hazardous waste materials. The in-place drying design for BRIC is expected to allow for high water recovery without the attendant complexity associated with attempting to mechanically remove, transport, and store the residual brine solids. The BRIC design also incorporates thin-film-drying processes and vacuum- and radiative-heat-transfer methods to increase the efficiency of the drying process and to promote options for fluid/solid management under conditions of microgravity; e.g., the use of capillary- and/or rotary-based design solutions.

A simplified diagram of the BRIC concept is shown in figure 1. Liquid brine is transferred to the evaporator using a metering pump or differential pressure between the evaporator and the ambient environment. A thin layer of brine spreads across the bottom of a disposable solids collection container. Spreading is accomplished by gravity and/or surface force interactions. Variable heat control and vacuum are supplied to facilitate evaporation and maintain temperatures at the desired set point. Water vapor from evaporating brine is transferred to a condensing heat exchanger via a vapor duct. The condensing heat exchanger is used to return purified water vapor to a liquid state. The condensate is then collected in the condensate tank. An optional recirculation loop that uses the vacuum pump exhaust or an additional blower may be incorporated to transfer vapor and aid in the overall evaporation process. A baffle or demister element in the vapor duct is used to prevent brine aerosols from entering the condensing

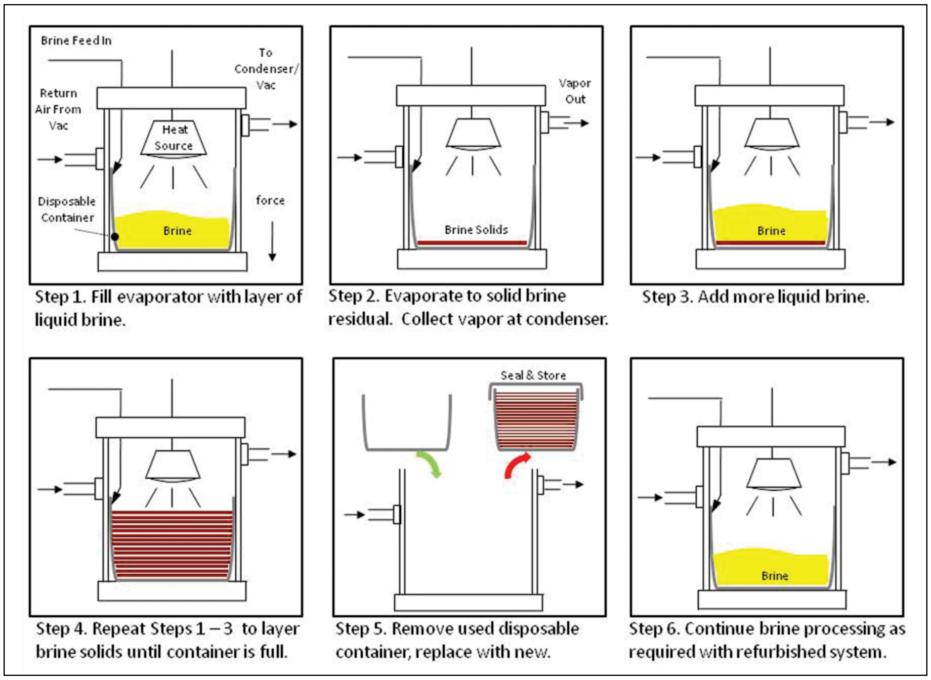

Fig. 2. Basic concept of brine residual in-containment operation.

Fig. 3. Brine residual in-containment pre-prototype.

chamber. In the current BRIC designs, direct radiative heat transfer and dielectric technologies, such as infrared and microwave systems, are currently being targeted as the evaporative heat source.

Figure 2 shows the steps involved in the basic concept of operation for the BRIC process. In Step 1, brine is introduced into the evaporator where it is contained for drying within a disposable solids collection container. In Step 2, the liquid brine is evaporated, the vapor process stream is recovered using the condenser, and the residual brine solids are held in place. More liquid brine is added to the evaporator in Step 3. In Step 4, the liquid brine injection and drying cycle is repeated until the solids collection chamber is full. In Step 5, the disposable solids collection chamber is sealed and removed, and a new solids collection chamber is installed in its place. The entire brine drying and solids collection process is repeated as noted in Step 6. A photograph of the BRIC pre-prototype is provided in figure 3.

Development of the BRIC concept has been in work for the past year. Efforts have focused on the design, buildup, and preliminary test of a pre-prototype laboratory demonstration unit. Tests conducted to date using both deionized water and as much as 16% sodium chloride solutions have demonstrated evaporation rates between 0.6 and 4.0 milliliters per minute (mL/min); as much as 95% water recovery; and the deposition, containment, and removal of a dried solid salt conglomerate. A new technology reporting disclosure for the BRIC was submitted to the NASA e-NTR system in late 2010. Current planning is under way to refine the BRIC process, establish system performance with actual brine waste streams, and develop a gravity-independent version of the dewatering system.